IS TECHNOLOGY CHANGING SOCIETY?

Commencement Address

by

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"What has been is that which shall be; and what has happened is that which shall happen. So that there is nothing new under the sun."

However, I think we stand, you and I and our children, at a monumental watershed in human history. I am sure that all of you have read much more than you care to about the human problems of the day: education for an unknown future, technological unemployment, the population explosion, the increasing level of violent crime and other evidence of the decay of institutions of control -- and our extraordinary technological developments, some of the more startling of which are the computer, molecular biology, particle physics, the laser, communication satellites, and the faltering first steps of space travel.

I would like to explore with you briefly the history of technical change and to raise the question as to whether great social change may not now attend it. I have two purposes in mind. First, to emphasize the utter interdependence and extremely powerful acceleration in very recent times of technical change, and secondly, to establish a scale that we can use to see how briefly our modern power has existed.

Henry Adams saw in the nineteenth century that there is a law of acceleration in history. The output of coal, of steam power, of electricity

increases geometrically, not arithmetically.

Here are a few examples of this law and some of its consequences for our generation and the ones to follow it.

From the concept of natural forces discovered by the Greeks over 2,000 years ago through gravity, electromagnetism, nuclear energy, to this decade's discovery of "weak" forces, observed in the decay of elementary particles, the time span between each discovery shrank geometrically.

The discovery of elements began 10,000 years ago with carbon, copper, iron, silver and gold. 9,900 years later in the last century, there were 60, but more than 40 have been added in this past 100 years.

The same kind of shrinkage occurred between the discoveries of the sources of energy: fire, water, wind, steam combustion, and nuclear energy.

These curves together show that our accumulated experience changes as much since the 19th century as our Victorian ancestors' experience had changed from that of men on the threshold of historic time.

There is evidence on all sides of us that this acceleration of science and technology, buttressed as it is by new research effort in this century, and estimated at more than $19 billion annually, is shutting off steadily and ominously opportunities for the uneducated while it is opening the future for those who can keep abreast -- and only trained and disciplined minds have any hope of keeping abreast.

Despite an enormous increase in our national product since the War, the number of people in factory jobs has declined. But the number of scientists and engineers has more than doubled, and the rate of increase gains constantly.

About twelve years ago the top 5% of incomes were dominated by the self-employed, the doctors, lawyers, farmers, small businessmen, followed by the white collar people, and finally scientists and engineers. By 1960 this was reversed; the scientists and engineers had reached the top.

In 1900 a tiny fraction of the leaders of industry had technical degrees; by 1960 it was 20%, and the percentage is rapidly rising. It is estimated that it will be 50% by 1980.

Thus the problem becomes crystal clear. According to the law of Adams, according to the evidence of these recent times, the managers of the future must cope with extraordinarily more complex phenomena. They can master them only if they can master tools and techniques of a subtlety almost infinitely greater than those used two decades ago before the age of the computer.

Dr. Lewis Leakey, the anthropologist, found in Africa the remains of a manlike creature that may well have been the earth's earliest user of tools. The age of its remains -- an assumption reinforced by subsequent research -- is estimated to be about one and three-quarter million years. It may be interesting and useful to think of this enormous time span in more familiar dimensions. If we consider the entire period of 1,750,000 years as one year,

then homosapiens - man as we know him-emerged on the day before Christmas. The next six days of the year, roughly corresponding to a 30 thousand year period, ended with man's establishment of the first permanent settlements based upon agriculture. The last day of the year was spent in inventing writing, pottery, and the atomic bomb. The industrial revolution started at about one half hour before midnight on the last day of our yardstick year. The airplane appeared at about 11:40 p. m. and atomic power at about five minutes to midnight.

The acceleration of technological and social change is particularly striking when we measure history with this one-year yardstick. Consider the population of the planet: It took mankind until 11:10 p. m. of the last day of our year to achieve a population of one billion. The second billion was added by 11:50 p. m., and the third billion was achieved at midnight. At the present rate of increase, the fourth billion will be on hand in only five minutes. Perhaps <u>one out of twenty of all humans who ever existed are alive right now</u>. At the present average growth rate of 2%, there will be in theory 1 square yard of earth per person in 600 years, or at 3:00 a. m. on our yardstick New Year's Day.

Technical change appears to be following the same explosive growth pattern. It is estimated that 90% of the scientists <u>of all time</u> are alive today, and that most of the scientific literature of the world has been published in the last ten years.

The wrenching changes in our social organization in recent times - bound up with the explosion in population and technology - are clear, I

imagine, to all of us. The magnitude of the changes that we have experienced and that are yet to come is perhaps not often seen in perspective; we are all too busy trying to keep our own footing in an unsteady world.

We are in what can fairly be called the end of the neolithic age. Today men in various parts of the world live at almost every level of cultural development, from primitive hunting-gathering groups to complex industrial civilizations. This is almost certainly the last century in which this diversity will exist, for increasing population, world-wide communications, the extraordinary increase in available energy, and the logic of industrial economics will force the development of a culture substantially held in common by all men.

All of man's existence to the time of ourselves and our children has been spent in the development of individual and diversified cultures. Small groups have grown until they overlap; they now are in the process of becoming an interdependent whole. Anthropologist and historian, Carrolton S. Coon, sees this development as the fourth phase of history, the first being the emergence of homo sapiens, the second homo sapiens' development in 30,000 years to the point where he created primitive settlements based on agriculture, the third a period of 6,000 years to the present in which he invented pottery, the use of metal, transportation from the wagon to the rocket, energy from the windmill and steam engine to electricity and atomic power, and communications from writing and printing to the telephone, computers, and the communication satellite.

The fourth phase of history has turned the trend of cultural differentiation that continued from neolithic times until World War II. We are starting to become a single cultural community at the dawn of the fourth phase of history.

The growth of two centrally important technologies -energy and communications - have been inextricably bound up with the birth, change and death of human institutions. Professor Coon observed that the number and complexity of institutions within societies regularly follow the changes in power consumption. He wrote in The Making of Man that, as man developed mechanical devices to utilize the increasing amount of energy available to him, there were produced, in the final analysis, progressive changes in the techniques of communication. "Through the agency of communication", Coon wrote, "these increases in energy consumption made possible the growth of new, large, more complex institutions, because the size of an institution depends on the ability of men to work together, possible only if they can communicate with one another."

Father Pierre Teilhard de Chardin, in his remarkable, though highly controversial book, "The Phenomenon of Man," described trends about which there can be no controversy, although the deductions he made are open to question from many quarters. He developed brilliantly the evolutionary trend toward mind and the growing interdependence and interpenetration of men's minds, and he stated the hypothesis that the goal of evolution is a single mind. Whether you agree or not with his projection

of this trend or its theological implications is, for the purposes of these remarks, unimportant. The important point is that de Chardin, and other perceptive observers of the past century, see that there is a rushing flood of demand upon men's minds; it is inexorable; it is irreversible if our civilization survives. For good or ill, no one who aspires to leadership in any field today can avoid the challenge that he, or she, to be competent, must be much more highly educated in science, particularly, than was true even a few decades ago.

While my view of the future of energy, communications, and human institutions is no better than any other glance into the crystal ball, I find in present technical trends a strong suggestion of their massive impact on our present institutions.

Let us first consider energy. The average amount of electrical power available to each person in the world is 216 watts, if the total capacity of all plants is taken into account. The distribution, of course, enormously favors industrial civilizations, where the availability of energy is the backbone of high industrial productivity. Here in the U.S. its about 6,000 watts per person. Two significant things appear to be happening to the energy available to human beings. First, it is growing greatly. A nuclear reactor is a very great energy source; the amount of power that can be drawn from it is limited only by the size of the heat exchange equipment. Used in a thermonuclear reaction, 230 cubic meters of water contain resources of energy equivalent to the total annual world production of coal. Solar energy is, of course, enormous, and we are learning how to use it.

Secondly, the economies of power generation indicate a scale of operation so big that it may help to render obsolete our traditional economic and political units. As fossil fuel plants are scaled up, their costs rise proportionately, the cost of a nuclear plant increases only about two thirds as its capacity doubles. Furthermore, huge high-voltage distribution systems carrying very large loads, which are logically associated with huge generating stations and high-cost switching gear, are given a boost by developments in superconductors. Alvin M. Weinberg, director of the Oak Ridge National Laboratory, writes that one calculation suggests that an economic optimum is a cable of about one inch diameter carrying 100,000,000 kilowatts - half the electricity of the United States! Transmission of power over 1,000 or even 2,000 miles is now possible. Power for New York City will come from Labrador.

N. N. Semenov, a member of the Soviet Association for the Advancement of Science and the recipient of the Nobel Prize for Chemistry in 1956, looks even deeper into the future, and estimates that the output of thermonuclear power on earth may be limited by the overheating of the atmosphere and earth's surface, and that we are likely to produce at most 5 to 10 percent of the solar energy absorbed by the earth and atmosphere. Semenov estimates that this would increase the amount of electrical energy several tens of thousands and thermal energy several hundred times over the present level.

When we reflect that major industrial revolutions have been instituted by changes that were on the order of 10^1 - one magnitude - increases in energy even approximating Semenov's estimate will have results staggering to imagine.

Communications, as I use the term, encompasses the capturing, manipulating, retrieving, transmitting, and presentation of information. It includes important elements of education, and is close to being the essence of humanism; our ability to draw upon the information created by those who went before us is an uniquely human ability. Communications technology is undergoing a revolution no less great than that experienced by energy. The manipulating and storing of data commonly associated with the computer is rapidly being supplemented by the ability to create information webs connecting associated computers or perhaps serving a single great machine. All of the data describing the citizens of a nation may eventually be collected in, and monitored by, a single machine. The information generated and needed by the increasing volume of human beings may necessitate an information store of unprecedented size and technical complexity, from which data can be entered and drawn from remote places, if the volume of data is not to overwhelm us.

The huge increase in energy and the equally huge improvement in technical communications, in their combination, and as one of their results, have produced something that we have been calling automation. John Diebold wrote that "...today's crop of machines deals with the very core of human

society - with information, its communication, and use ... These are developments that augur far more for mankind than net changes in manpower, more or less employment, or new ways of doing old tasks ... This is a technology which vastly extends the range of human capability and which will fundamentally alter human society and force us to reconsider our whole approach toward society, and to life itself".

One of these changes, accelerated but not begun by automation, is the disappearance of work as we have until now generally understood it. Increased productivity supported by great power resources and reservoirs of information will make the satisfaction of total material needs possible without expending on their production a large fraction of the currently available manhours. As the population must, of course, receive this output for their use - this is the real reason for producing anything - some way must be found to give people purchasing power that is increasingly independent of the hours spent doing things that have represented the great bulk of the world's work up to now. We must, quite simply, invent a new kind of money, a new way of distributing the material wealth of our society - a task for the innovators of banking.

How prepared are we to make the social inventions, the practical nontechnical plans, for the changes in our institutions that these developments are forcing upon us? John Dewey wrote in 1922 that, "... our science of human nature in comparison with physical sciences is rudimentary, and morals which are concerned with the health, efficiency and happiness of a

development of human nature are correspondingly elementary." Unfortunately, I doubt that Dewey could have reached a different conclusion if he wrote today.

We cannot leave the development of the new social systems, the collaboration of men in the changing world culture, entirely to chance. We desperately need the help of social sciences that impart practical skills directly useful in human relations, a test that so far has been conspicuously failed. As Professor Coon wrote, "we need not only men who can handle complicated machinery and read dials, but also men who can think in large terms. Until recently the world had gone its own way innocent of planning except for the most essential rules of human relations as expressed in the most fundamental doctrines of religion. We must not - we cannot - leave these developments to chance.

We have touched on three important variables - population, energy, communications - that will influence in a profound and incompletely understood way the social institutions of the future, and we have seen the grave importance of achieving practical and effective social sciences that can help to keep us out of the ditch.

Technological growth and change is inevitably exerting profound and terribly complex pressures on society all over the world. The influence which these pressures are bringing to bear is, and will be, increasingly relentless in creating change. Whether this change will ultimately bring a happier and more rewarding existence for man depends on how well we behave while change accelerates.

Accordingly, we must assume that the necessity for understanding science is accompanied by an equally essential responsibility for understanding the social sciences; -- else we humans may perish.

Can we in the face of geometrically exploding innovative discoveries which affect every facet of our lives, fail to see that our management of physical forces is an important thing but no more so than our spiritual attitudes and that these latter are more likely to determine our fate.

It is a weary cliche to stand before young people, clutching the first physical credentials attesting to a degree of education, and tell them that they are facing change and challenge. Today, however, if these credentials hold any real validity, any shred of reality, you must know that what you are confronted with is quite simply the need for a revolution in attitude.

The achievements of science cause the necessity for accompanying new social insight in "your generation," and hopefully your reactions will be serious and lasting concerns. This may be the first time in history when the concern of educated young people all over the world must be focused on the welfare of their fellow human beings. If you have been good students of current history, you will appreciate that your instincts are not significantly different from those of your contemporaries everywhere.

If your willingness to experiment socially is as great as it appears, you, for once, have a chance to turn frightening technological advances into useful and constructive tools for social advancement. For example, if they provide you with sophisticated tools of communication instead of tools of destruction, you may be on the right path towards achieving balance

between catastrophe and utopia. When you understand them and use them with design and loving care, you will find that what may appear to you to be evils of modern technology are instead essential attributes of a modern humanism.

After rather grim considerations of this sort, it is well to reread the verse attributed to Koheleth. A version appears in Ecclesiastes, but the earlier text is, I think, more beautiful.

> What gain has a man of all his toil, which he
> toils under the sun?
>
> Generation comes and generation goes, but
> the earth remains forever.
>
> The sun rises and the sun sets, and to his
> rising place he returns.
>
> . . . all streams flow into the sea, but the
> sea is not full.
>
> To the place whither the streams flow, from
> there they flow back again.
>
> Everything is wearied,
> beyond human utterance
> beyond sight and hearing.
> What has been is that which shall be; and what
> has happened is that which shall happen,
> so that there is nothing new under the sun.

Perhaps if Koheleth lived with us in these changing times, he might find, as we and our children certainly will, something completely new, perhaps disturbing, or perhaps exhilarating, under the sun.

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